Clean Copy of Allowed Claims

1. A method for fabrication of a diesel engine turbocharger turbine stage, comprising the steps of:

selecting a set of discrete throttle settings for the engine, wherein the selected discrete throttle settings correlate to discrete rotational speeds of the turbocharger;

modeling the turbocharger for the engine, including modeling of the turbine stage thereof for vibration analysis, said modeling of the turbine stage further comprising modeling of turbine blades of a turbine wheel and modeling turbine nozzle vanes;

determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

determining a turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting; and

ascertaining whether a data coincidence is present at each of the throttle settings, said step of ascertaining comprising determining whether, at the rotational speed corresponding to that throttle setting, there is a data coincidence of said one or more natural frequencies of vibration and said turbine nozzle vane induced turbine blade excitation frequency;

wherein if there is an absence of said data coincidence at each of the throttle settings, the turbine stage fabricated according to said step of ascertaining will have turbine blades which are at least substantially free of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger.

2. The method of Claim 1, wherein the data coincidence comprises a predetermined range of proximity of the rotational speed corresponding to each throttle setting, said one or more natural frequencies of vibration at that throttle setting, and said turbine nozzle vane induced turbine blade excitation frequency at that throttle setting.

3. The method of Claim 2, further comprising fabricating the turbocharger according to said step of ascertaining whether a data coincidence is present at each of the throttle settings for the engine, wherein said step of ascertaining indicates that the turbocharger is free of said data coincidence at each of the throttle settings, indicating absence of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger.

4. A turbocharger turbine stage for a diesel engine fabricated such that it is free of harmonically resonant vibrations at a set of discrete rotational speeds of the turbocharger corresponding to a set of discrete throttle settings for the engine, wherein an absence of harmonically resonant vibrations at discrete rotational speeds is determined by a method comprising:

selecting the set of discrete throttle settings for the engine, wherein the selected discrete throttle settings correlate to discrete rotational speeds of the turbocharger;

modeling the turbocharger for the engine, including modeling of the turbine stage thereof for vibration analysis, said modeling of the turbine stage further comprising modeling of turbine blades of a turbine wheel and modeling turbine nozzle vanes;

determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

determining a turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting; and

ascertaining whether a data coincidence is present at each of the throttle settings, said step of ascertaining comprising determining whether, at the rotational speed corresponding to that throttle setting, there is a data coincidence of said one or more natural frequencies of vibration and said turbine nozzle vane induced turbine blade excitation frequency;

wherein if there is an absence of said data coincidence at each of the throttle settings, the turbine stage fabricated according to said step of ascertaining will have turbine blades which are at least substantially free of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger.

5. The method of Claim 6, further comprising repeating:

the step of modeling, wherein the repeating of said step of modeling comprises remodeling of turbine blades of the turbine wheel for vibration analysis;

the step of determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

the step of determining the turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting;

the step of ascertaining whether a data coincidence is present at each of the throttle settings; and

the step of modifying at least one of configuration and material composition of the turbine blades;

until the absence of data coincidence at the rotational speed corresponding to each throttle setting is obtained.

6. The method of Claim 2, wherein when a presence of any data coincidence is determined by the step of ascertaining, modifying at least one of configuration and material composition of the turbine blades.

7. The method of Claim 2, further comprising fabricating the turbocharger according to said step of ascertaining whether a data coincidence is present at each of the throttle settings for the engine, wherein:

when a presence of any data coincidence is determined by the step of ascertaining, modifying at least one of configuration and material composition of the turbine blades; and

repeating:

the step of modeling, wherein the repeating of said step of modeling comprises remodeling of turbine blades of the turbine wheel for vibration analysis;

the step of determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

the step of determining the turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting;

the step of ascertaining whether a data coincidence is present at each of the throttle settings; and

the step of modifying at least one of configuration and material composition of the turbine blades;

until the absence of data coincidence at the rotational speed corresponding to each throttle setting is obtained.

8. A turbocharger turbine stage for a diesel engine fabricated such that it is free of harmonically resonant vibrations at a set of discrete rotational speeds of the turbocharger corresponding to a set of discrete throttle settings for the engine, wherein an absence of harmonically resonant vibrations at discrete rotational speeds is determined by a method comprising:

selecting the set of discrete throttle settings for the engine, wherein the selected discrete throttle settings correlate to discrete rotational speeds of the turbocharger;

modeling the turbocharger for the engine, including modeling of the turbine stage thereof for vibration analysis, said modeling of the turbine stage further comprising modeling of turbine blades of a turbine wheel and modeling turbine nozzle vanes;

determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

determining a turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting; and

ascertaining whether a data coincidence is present at each of the throttle settings, said step of ascertaining comprising determining whether, at the rotational speed corresponding to that throttle setting, there is a data coincidence of said one or more natural frequencies of vibration and said turbine nozzle vane induced turbine blade excitation frequency;

wherein if there is an absence of said data coincidence at each of the throttle settings, the turbine stage fabricated according to said step of ascertaining will have turbine blades which are

at least substantially free of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger; and

wherein when a presence of any data coincidence is determined by the step of ascertaining,

modifying at least one of configuration and material composition of the turbine blades; and

repeating:

the step of modeling, wherein the repeating of said step of modeling comprises remodeling of turbine blades of the turbine wheel for vibration analysis;

the step of determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

the step of determining the turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting;

the step of ascertaining whether a data coincidence is present at each of the throttle settings; and

the step of modifying at least one of configuration and material composition of the turbine blades;

until the absence of data coincidence at the rotational speed corresponding to each throttle setting is obtained.

9. The method of Claim 2, wherein said step of modeling further includes selecting a number of said turbine nozzle vanes; further when a presence of any data

coincidence is determined by the step of ascertaining, further changing the number of said turbine nozzle vanes and remodeling turbine nozzle vanes.

10. The method of Claim 9, wherein the step of remodeling of the turbine nozzle vanes further includes selecting an odd, prime number of turbine nozzle vanes.

11. The method of Claim 2, further comprising fabricating the turbocharger according to said step of ascertaining whether a data coincidence is present at each of the throttle settings for the engine, wherein:

when a presence of any data coincidence is determined by the step of ascertaining, changing the number of said turbine nozzle vanes and remodeling turbine nozzle vanes such that there are no harmonically resonant vibrations at the discrete rotational speeds of the turbocharger corresponding to discrete throttle settings of the diesel engine;

wherein an odd, prime number of turbine nozzle vanes is selected when changing the number of said turbine nozzle vanes.

12. A turbocharger turbine stage for a diesel engine fabricated such that it is free of harmonically resonant vibrations at a set of discrete rotational speeds of the turbocharger corresponding to a set of discrete throttle settings for the engine, wherein an absence of harmonically resonant vibrations at discrete rotational speeds is determined by a method comprising:

selecting the set of discrete throttle settings for the engine, wherein the selected discrete throttle settings correlate to discrete rotational speeds of the turbocharger;

modeling the turbocharger for the engine, including modeling of the turbine stage thereof for vibration analysis, said modeling of the turbine stage further comprising modeling of turbine blades of a turbine wheel and modeling turbine nozzle vanes;

determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

determining a turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting; and

ascertaining whether a data coincidence is present at each of the throttle settings, said step of ascertaining comprising determining whether, at the rotational speed corresponding to that throttle setting, there is a data coincidence of said one or more natural frequencies of vibration and said turbine nozzle vane induced turbine blade excitation frequency;

wherein if there is an absence of said data coincidence at each of the throttle settings, the turbine stage fabricated according to said step of ascertaining will have turbine blades which are at least substantially free of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger; and

wherein when a presence of any data coincidence is determined by the step of ascertaining,

changing the number of said turbine nozzle vanes and remodeling turbine nozzle vanes such that there are no harmonically resonant vibrations at the discrete rotational speeds of the turbocharger corresponding to discrete throttle settings of the diesel engine;

wherein an odd, prime number of turbine nozzle vanes is selected when changing the number of said turbine nozzle vanes.

13. Canceled.

14. Canceled.

15. Canceled.

16. Canceled.

17. A method for fabrication of a diesel engine turbocharger turbine stage, comprising the steps of:

selecting a set of discrete throttle settings for the engine, wherein the selected discrete throttle settings correlate to discrete rotational speeds of the turbocharger;

modeling the turbocharger for the engine, including modeling of the turbine stage thereof for vibration analysis, said modeling of the turbine stage further comprising modeling of turbine blades of a turbine wheel and modeling turbine nozzle vanes,;

determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

determining a turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting; and

ascertaining whether a data coincidence is present at each of the throttle settings, said step of ascertaining comprising determining whether, at the rotational speed corresponding to that throttle setting, there is a data coincidence of said one or more natural frequencies of vibration and said turbine nozzle vane induced turbine blade excitation frequency;

wherein the data coincidence comprises a predetermined range of proximity of the rotational speed corresponding to each throttle setting, said one or more natural frequencies of vibration at that throttle setting, and said turbine nozzle vane induced turbine blade excitation frequency at that throttle setting;

wherein if there is an absence of said data coincidence at each of the throttle settings, the turbine stage fabricated according to said step of ascertaining will have turbine blades which are at least substantially free of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger; and

wherein when a presence of any data coincidence is determined by the step of ascertaining,

performing one of redesigning the turbine blades of the turbine wheel and redesigning turbine nozzle vanes;

wherein redesigning the turbine blades of the turbine wheel comprises:

modifying at least one of configuration and material composition of the turbine blades; and repeating:

the step of modeling, wherein the repeating of said step of modeling comprises remodeling of turbine blades of the turbine wheel for vibration analysis;

the step of determining one or more natural frequencies of vibration of the turbine blades for each of the throttle settings;

the step of determining the turbine nozzle vane induced turbine blade excitation frequency as a function of the turbocharger rotational speed at that throttle setting;

the step of ascertaining whether a data coincidence is present at each of the throttle settings; and

the step of modifying at least one of configuration and material composition of the turbine blades;

until the absence of data coincidence at the rotational speed corresponding to each throttle setting is obtained; and

wherein redesigning turbine nozzle vanes comprises:

changing the number of said turbine nozzle vanes and remodeling turbine nozzle vanes;

wherein the step of remodeling of the turbine nozzle vanes includes selecting an odd, prime number of turbine nozzle vanes.

18. The method of Claim 17, further comprising fabricating the turbocharger according to said step of ascertaining whether a data coincidence is present at each of the throttle settings for the engine, wherein said step of ascertaining indicates that the turbocharger is free of said data coincidence at each of the throttle settings, indicating absence of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger.

19. The method of Claim 17, further comprising selecting a new throttle setting without encountering a data coincidence such that the turbocharger remains within a region of safe operation.

20. The method of Claim 19, further comprising fabricating the turbocharger according to said steps of redesigning, modeling and modifying, wherein said step of ascertaining indicates that the turbocharger is free of said data coincidence at each of the

throttle settings, indicating absence of harmonically resonant vibrations at the discrete rotational speeds of the turbocharger.